

CLAIMS

We Claim:

1. A composition comprising particles having an inner and an outer region, wherein the inner region comprises a cubic spinel lithiated manganese oxide, and the outer region is enriched in Mn^{+4} relative to the inner region.
2. A composition according to Claim 1, wherein the cubic spinel lithiated manganese oxide is represented by the formula $\text{Li}_{1+x}\text{Mn}_{2-x}\text{O}_4$ where x is greater than or equal to 0 and less than 0.2.
3. A composition according to Claim 1, wherein in the outer region the ratio of manganese to oxygen, as determined by x-ray photoelectron spectroscopy, is about 1 to 3.
4. A composition according to Claim 1, wherein the outer region comprises Li_2MnO_3 .
5. A composition according to Claim 1, wherein the outer region comprises Na_2MnO_3 .

6. A composition according to Claim 1, wherein the composition is prepared from starting material cubic spinel lithiated manganese oxide particles by reacting the starting material particles with a alkali metal compound in the presence of oxygen for a time and at a temperature sufficient to oxidize at least a portion of the Mn^{+3} in the cubic spinel starting material particles to Mn^{+4} .

7. A composition according to claim 6, wherein the composition is characterized by a lattice parameter a that is larger than the parameter a of untreated spinel lithiated manganese oxide particles.

8. A composition according to claim 6, wherein the composition is characterized by a lattice parameter a that is smaller than the parameter a of untreated spinel lithiated manganese oxide particles.

9. A composition according to Claim 6, wherein the alkali metal compound comprises a carbonate.

10. A composition according to claim 6, wherein the alkali metal compound comprises a hydroxide.

11. A composition according to claim 6, wherein the alkali metal compound comprises a phosphate, hydrogen phosphate, or dihydrogen phosphate.

12. A composition according to Claim 6, wherein the alkali metal compound comprises sodium carbonate.
13. A composition according to Claim 6, wherein the alkali metal compound comprises lithium carbonate.
14. A composition according to Claim 6, wherein oxidation to Mn^{+4} occurs at the surface of the starting material cubic spinel lithiated manganese oxide particles.
15. A composition according to Claim 6, wherein the composition is enriched in lithium relative to the starting material cubic spinel lithiated manganese oxide.
16. A treated active material in the form of particles having an inner region and an outer region and comprising cubic spinel lithiated manganese oxide and Li_2MnO_3 , comprising the reaction product of starting material cubic spinel lithiated manganese oxide particles, a lithium compound, and oxygen.
17. An active material according to Claim 16, wherein the lithium compound comprises lithium carbonate.
18. An active material according to Claim 16, wherein the Li_2MnO_3 is present in greater amounts in the outer region than in the inner region.

19. An active material according to Claim 16, wherein Li_2MnO_3 is present in the inner region.
20. An active material according to Claim 16, comprising an inner region of cubic spinel lithiated manganese oxide and an outer region of Li_2MnO_3 .
21. A treated active material in the form of particles having an inner and an outer region and comprising cubic spinel lithiated manganese oxide and Na_2MnO_3 , comprising the reaction product of starting material cubic spinel lithiated manganese oxide particles, a sodium compound, and oxygen.
22. An active material according to Claim 21, wherein the sodium compound comprises sodium carbonate.
23. An active material according to Claim 21, wherein the Na_2MnO_3 is present in greater amounts in the outer region than in the inner region.
24. An active material according to Claim 21, wherein Na_2MnO_3 is present in the inner region.
25. An active material according to Claim 21, comprising an inner region of cubic spinel lithiated manganese oxide and an outer region of Na_2MnO_3 .

26. An electrode for use in a lithium ion battery, comprising an active material and a binder, wherein the active material comprises particles having an inner and an outer region, wherein the inner region comprises a cubic spinel lithiated manganese oxide, and the outer region is enriched in Mn^{+4} relative to the inner region.

27. An electrode according to claim 26, wherein the cubic spinel lithiated manganese oxide is represented by the formula $\text{Li}_{1+x}\text{Mn}_{2-x}\text{O}_4$ where x is greater than or equal to 0 and less than 0.2.

28. An electrode according to claim 26, wherein the outer region comprises Li_2MnO_3 .

29. An electrode according to Claim 26, wherein the outer region comprises Na_2MnO_3 .

30. An electrode according to Claim 26, wherein the active material is prepared from starting material cubic spinel lithiated manganese oxide particles by reacting the starting material particles with an alkali metal compound in the presence of oxygen for a time and at a temperature sufficient to oxidize at least a portion of the Mn^{+3} in the cubic spinel starting material particles to Mn^{+4} .

31. An electrode according to claim 30, wherein the active material is characterized by a lattice parameter a that is larger than the lattice parameter a of untreated spinel particles.
32. An electrode according to claim 30, wherein the active material is characterized by a lattice parameter a that is smaller than the lattice parameter a of untreated spinel particles.
33. An electrode according to Claim 30, wherein the alkali metal compound comprises a carbonate.
34. An electrode according to claim 30, wherein the alkali metal compound comprises a hydroxide.
35. An electrode according to claim 30, wherein the alkali metal comprises a phosphate, hydrogen phosphate, or dihydrogen phosphate.
36. An electrode according to Claim 30, wherein the alkali metal compound comprises lithium carbonate.
37. An electrode according to Claim 30, wherein the alkali metal compound comprises sodium carbonate.

38. An electrode according to claim 30, wherein the active material is enriched in lithium relative to the starting material cubic spinel lithiated manganese oxide.

39. A battery comprising a positive electrode, a negative electrode, and an electrolyte, wherein the positive electrode comprises an active material comprising particles having an inner and an outer region, wherein the inner region comprises a cubic spinel lithiated manganese oxide, and the outer region is enriched in Mn^{+4} relative to the inner region.

40. A battery according to claim 39, wherein the cubic spinel lithiated manganese oxide is represented by the formula $Li_{1+x}Mn_{2-x}O_4$ where x is greater than or equal to 0 and less than 0.2

41. A battery according to claim 39, wherein the outer region of the active material particles comprises Li_2MnO_3 .

42. A battery according to Claim 39, wherein the outer region of the active material particles comprises Na_2MnO_3 .

43. A battery according to claim 39, wherein the active material is prepared from starting material cubic spinel lithiated manganese oxide particles by reacting the starting material particles with an alkali metal compound in the presence of oxygen for a time and at a temperature sufficient to oxidize at least a portion of the Mn^{+3} in the cubic spinel starting material particles to Mn^{+4} .

44. A battery according to claim 39, wherein the active material is enriched in lithium relative to the starting material cubic spinel lithiated manganese oxide.